



LTCS (Laser Thermal Control System) test supporting the improvement of DeCoM (Deepak Condenser Model) (Deepak Patel / NASA GSFC)

Presented By
(Deepak Patel)

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Lead Thermal Engineer on ATLAS
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Sr. Thermal Engineer at GSFC
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Loop Heat Pipe Expert
- **Thermal Engineering Branch at Goddard Space Flight Center**



Structure

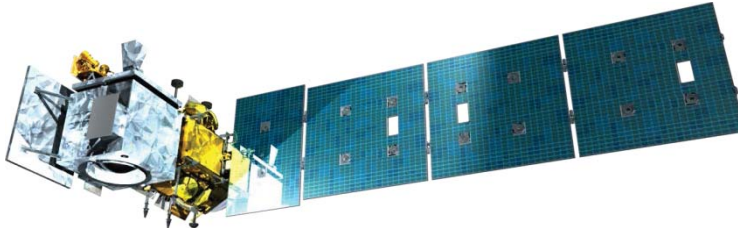


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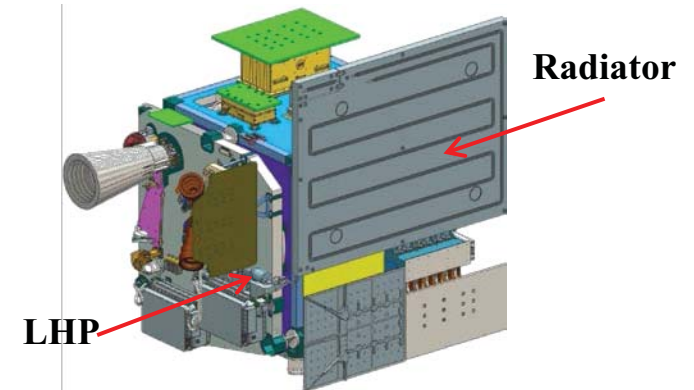
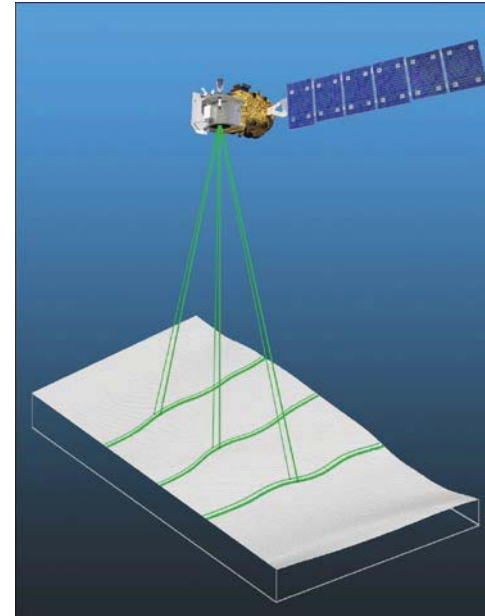


ATLAS Introduction

Science Objective/LTCS Purpose



- The objective of ICESat-2 is to collect altimetric measurements of Earth's surface, optimized to measure heights and freeboard of polar ice.
- ATLAS (Advanced Topographic Laser Altimeter System) instrument, sole for the mission, carries two lasers onboard. Only one laser is operational at any given time. The test that this presentation will cover is of the LTCS (Laser Thermal Control System) that was designed to maintain temperature of the operational laser.



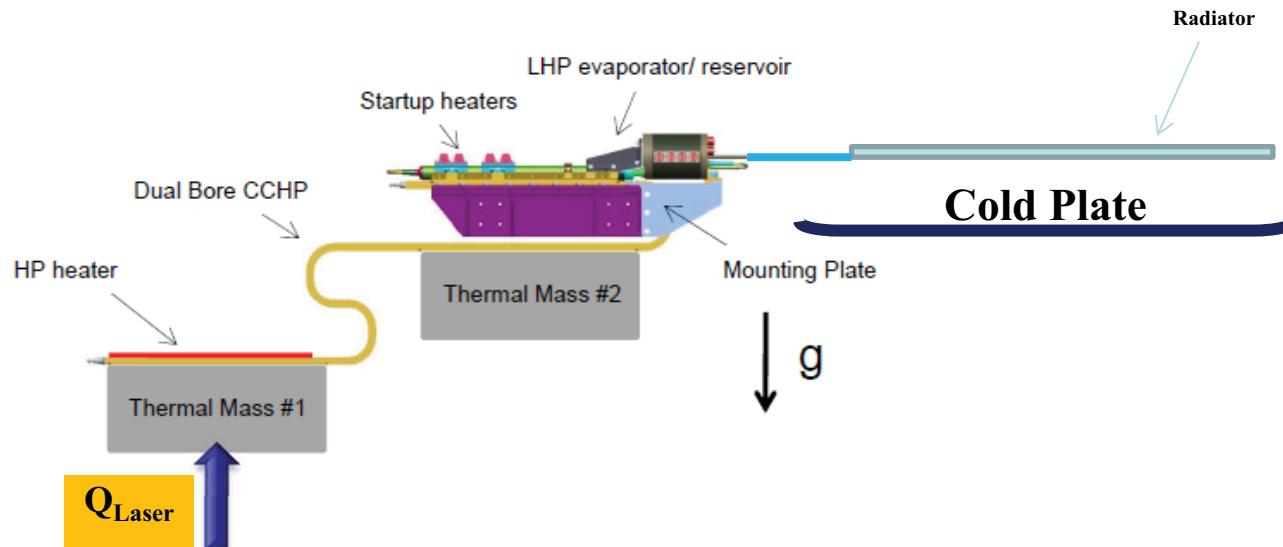
LTCS Assembled with ATLAS



LTCS Test Description



- Flight laser thermal control system (LTCS) comprises of a loop heat pipe, constant-conductance heat pipe, and a radiator
 - Heat pipe and LHP both operating in reflux
 - The test comprises of thermal masses that have similar capacitance that of the flight lasers.
 - The radiator coated surface was the only exposed area to the shroud, everything else was blanketed.

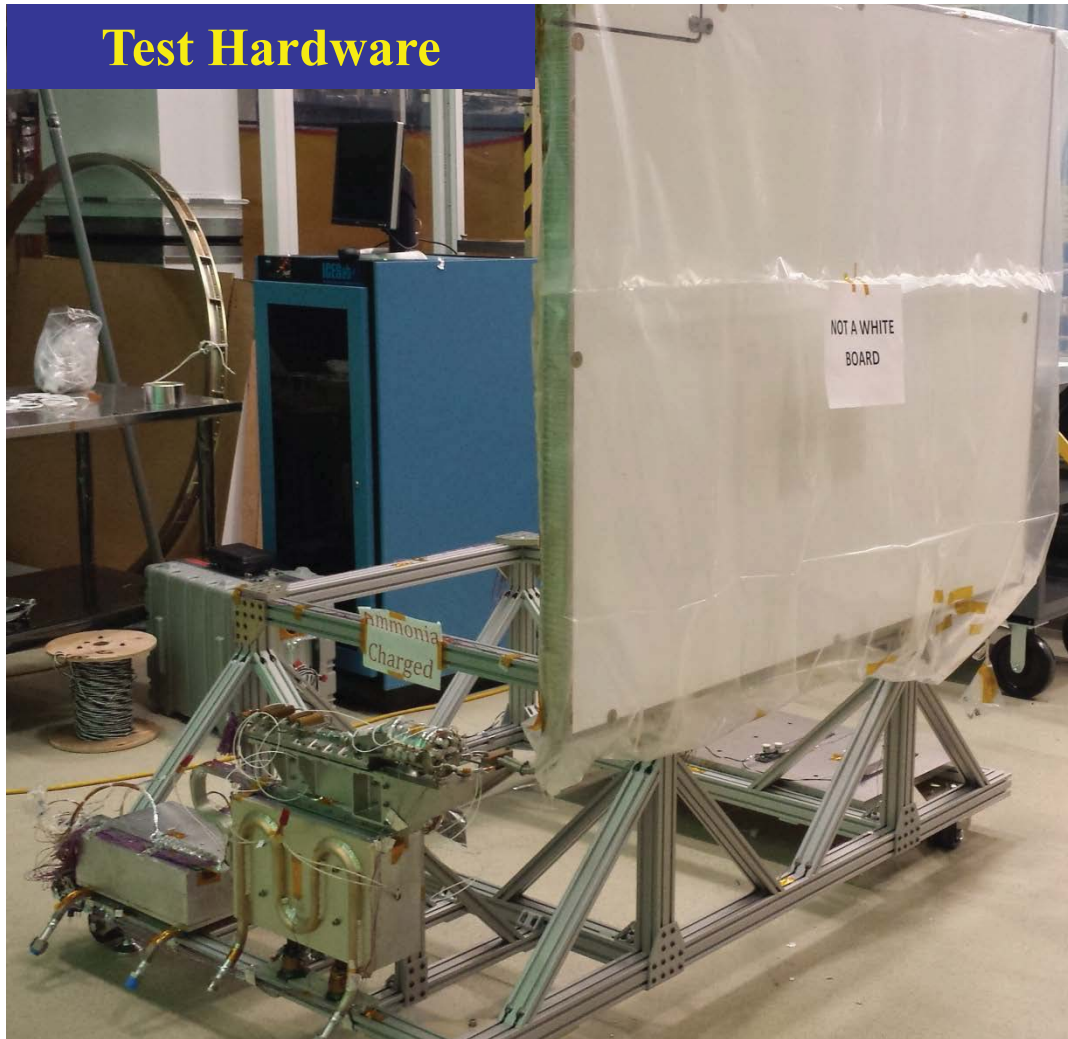




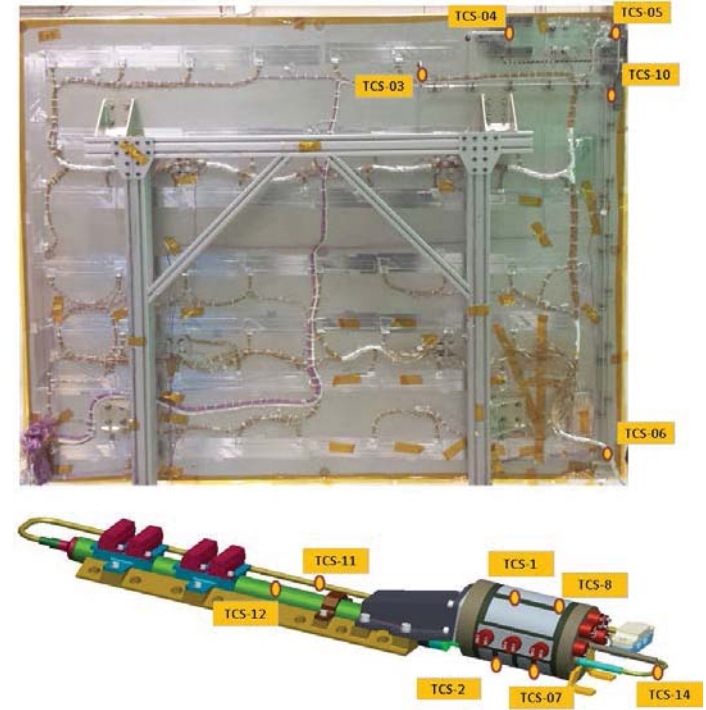
LTCS Test Description



Test Hardware



Test Temperature Sensors

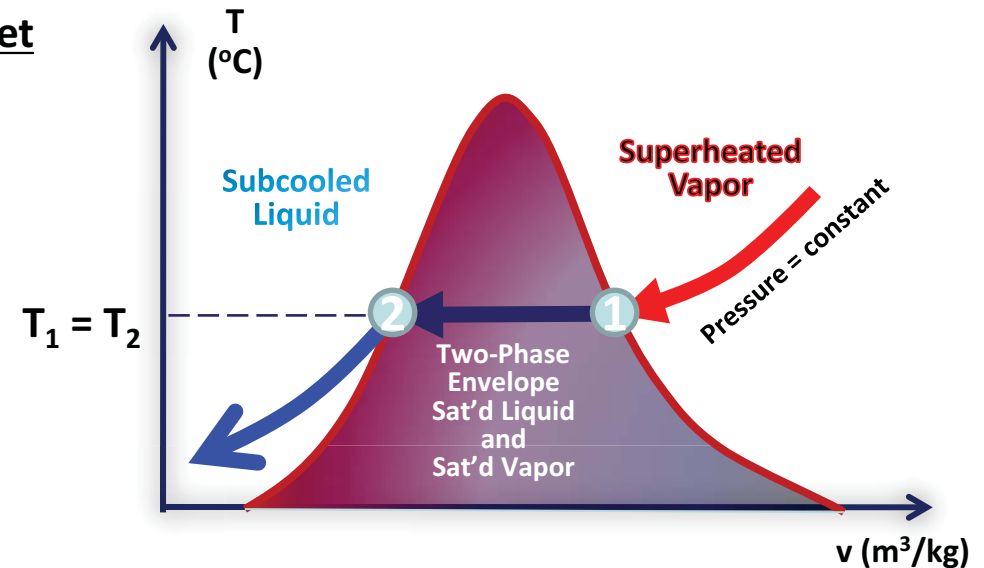
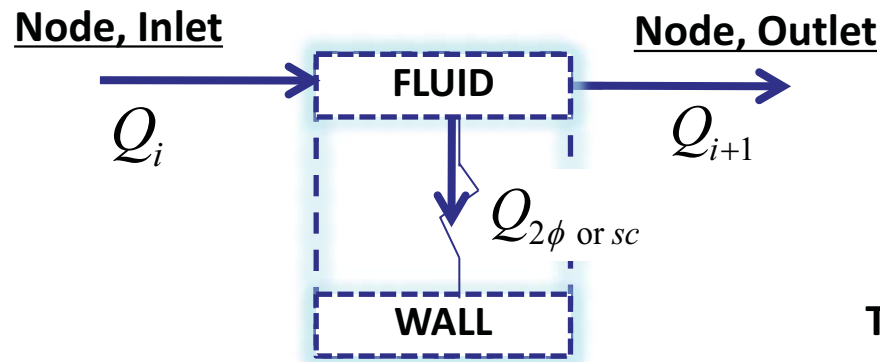




DeCoM Introduction



- DeCoM was developed through the need to predict fluid behavior. Benefit of DeCoM over other software's was that it was home grown, and no licenses were required.

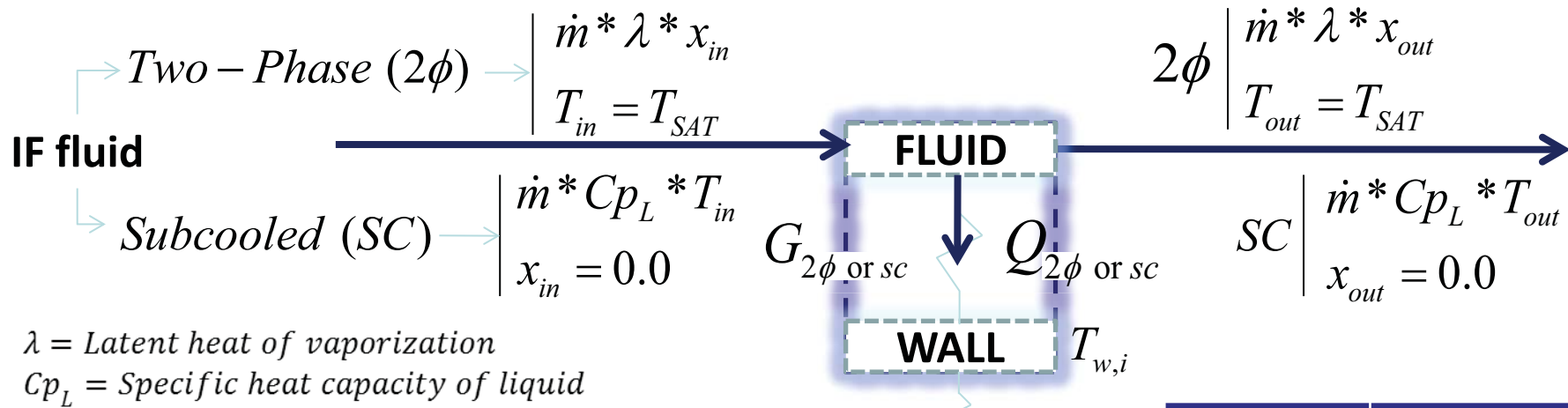


$$\sum Q_{in} = \sum Q_{out} \quad \rightarrow \text{Conservation of Energy}$$

- Condenser source code is based on the Conservation of Energy equation. Applied on each node.



DeCoM Introduction – Governing Equations



$$Q_{2\phi} = \dot{m} * \lambda * \Delta x$$

➤ **2-Phase section** ↓

$$Q_{sc} = \dot{m} * C_{p_l} * \Delta T$$

➤ **Subcooled section**

- Inlet conditions are known
- Equations can vary depending upon the state of the fluid (2ϕ or SC), as shown above.
- *Lockhart-Martinelli* equations are used to solve for the $G_{2\phi}$ value.

UNKNOWN	KNOWN
x_{out} if 2ϕ	T_{wi}, T_{fi} x_{in} $G_{2\phi}(x_{in})$ $Q_{2\phi}(G_{2\phi}, T_{wi})$
T_{OUT} if SC	T_{wi} T_{IN} G_{SC} $Q_{SC}(G_{SC}, T_{wi})$



DeCoM Introduction – Addition



- A new feature that's been added to the code allows the user to let the code decide what correlation method to apply for verifying phase transition.
 - The user can also manually select one of 5 of the following methods, pre-built into the code:
 - Muller-St and Heck Correlation
 - Shah Correlation
 - Lockhard and Martinelli Correlation
 - Results closely match test data using this method
 - Friedel Correlation
 - Chisholm Correlation
- The code chooses the correlation method based on ratio of liquid and vapor dynamic viscosity, and mass velocity.
 - This approach was tested by Whalley (1980) with extensive comparison between various published correlations (with over 25,000 data points)
 - Ref: Wolverine Tube, Inc Engineering Data Book III

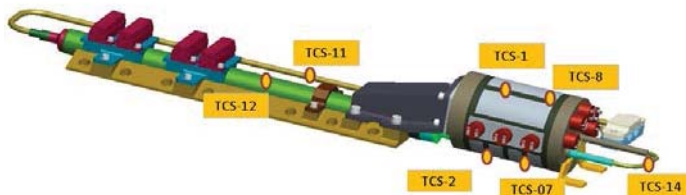


DeCoM Predictions



- Data comparison shows that DeCoM predicted temperatures of the condenser line within a degree on average.

Test Temperature Sensors



<u>Sensor</u>	<u>Test Data</u>	<u>DeCoM (Thermal Model)</u>	<u>DT</u>
[C]			
<u>Balance 1H</u>			
TCS-12	13.54	13.61	-0.07
TCS-03	11.15	13.61	-2.47
TCS-04	-9.04	-10.62	1.58
TCS-05	-16.37	-16.9	0.53
<u>Balance 2H</u>			
TCS-12	8.58	8.61	-0.03
TCS-03	6.29	8.61	-2.32
TCS-04	-16.38	-13.88	-2.50
TCS-05	-21.36	-20.47	-0.89
<u>Balance 4H</u>			
TCS-12	-13.35	-13.61	0.26
TCS-03	-14.47	-13.61	-0.86
TCS-04	-25.14	-23.11	-2.03
TCS-05	-26.79	-27.19	0.40
<u>Balance 9H</u>			
TCS-12	-6.27	-5.48	-0.79
TCS-03	-7.38	-5.48	-1.90
TCS-04	-18.56	-16.62	-1.94
TCS-05	-20.36	-21.47	1.11
<u>Balance 10H</u>			
TCS-12	6.85	6.39	0.46
TCS-03	5.33	6.39	-1.06
TCS-04	-10.84	-9.3	-1.54
TCS-05	-12.87	-15.51	2.64



Future Work



- Make the code more user friendly
 - Compile the code for better file transport
 - Combine two files into one
 - Currently there is a file for creating thermal network and one for performing fluid calculations
- Correlate more data points for reliability
 - Increase code confidence
- Include pressure drop calculations
 - Be able to calculate condenser pressure drops for use towards the larger loop heat pipe system pressure drop calculations.